

## **California's Renewable Energy Goals— Assessing the Need for Additional Transmission Facilities**

### **Introduction**

California's Renewable Energy Transmission Initiative (RETI) has been given the mission of identifying new transmission facilities that likely would be required to enable the state to achieve greenhouse gas emissions reduction and renewable energy goals.<sup>1</sup>

Most current planning has found large-scale geothermal, solar and wind projects to provide the fastest, most feasible and cost-effective path toward meeting these goals. In California, the highest quality renewable resources remaining to be developed are concentrated in relatively small geographic areas. This moderates the cost and impacts of accessing them, but would require major new transmission lines.

Alternative assumptions about energy efficiency and renewable energy development could reduce or eliminate the need for large wind and solar generating projects and associated transmission. This paper provides a framework for assessing key drivers of electric demand and supply underlying transmission planning. It addresses these considerations:

1. RETI Mission and Planning Assumptions
2. Demand for Electricity and California Population Growth
3. Accelerated Energy Efficiency Savings
4. Accelerated Deployment of Distributed PV
5. Development Cost and Risk Factors Underlying Transmission Planning Assumptions

### **1. RETI Mission and Planning Assumptions**

RETI is an advisory body with no authority to make an official determination of need for such facilities or to determine whether such facilities meet the requirements of CEQA and/or NEPA.<sup>2</sup>

Current state legislation requires 20% of all electric energy delivered to California consumers be generated from qualified renewable energy resources by the year 2010.<sup>3</sup> State policy embodied in the Energy Action Plan adopted by the CPUC, Energy Commission and Governor Schwarzenegger increases this fraction to 33%.<sup>4</sup> RETI has been directed to plan to achieve this target.

In 2007, 35,545 gigawatt-hours (GWh) of electric energy were generated from qualified renewable energy resources for California consumers, approximately 12% of all electric energy sold.<sup>5</sup> In Phase 1, RETI considered how much additional electricity is likely to be needed in California by 2020, and how much of that additional electricity is likely to be generated from remote renewable energy resources that would require new transmission facilities to be constructed in order to deliver this energy to cities.

The additional amount of remote renewable energy requiring transmission to meet the state's goal is referred to as the "renewable net short", as described in the Phase 1B Final Report posted on the RETI web site.<sup>6</sup>

Since the future is uncertain, both the total amount of electric energy California will need in 2020 and the RETI net short cannot be known precisely. As described in the Phase 1B report, for purposes of transmission planning RETI uses a value of 335,644 GWh for the total electric energy demand in the year 2020.

RETI also assumes that the current renewable energy supply of 35,545 GWh will continue to be available in 2020. In addition, some of the additional renewable supply needed to attain the 33% goal will be met with resources currently under development, from small projects of various technologies not needing major transmission facilities, and from increasing use of photovoltaic (PV) and other generation technologies in urban areas which also do not require new high voltage transmission facilities. The renewable net short represents the remaining renewable energy from remote resource areas requiring new transmission, estimated to be an additional 67,536 GWh.<sup>7</sup>

In comments received on the draft Phase 1B report, several parties noted that energy scenarios other than those used by RETI to estimate the renewable net short are possible. Some of those commenting claimed that alternative scenarios are even likely, perhaps even avoiding the need for new transmission facilities altogether.

However, transmission planning, permitting and construction require lead times of seven-ten years. Plans developed in RETI Phase 3 are unlikely to be operational before about 2015. If the RETI estimate of the renewable net short is approximately correct and California is to meet its energy goals, planning for the transmission required must begin at once.

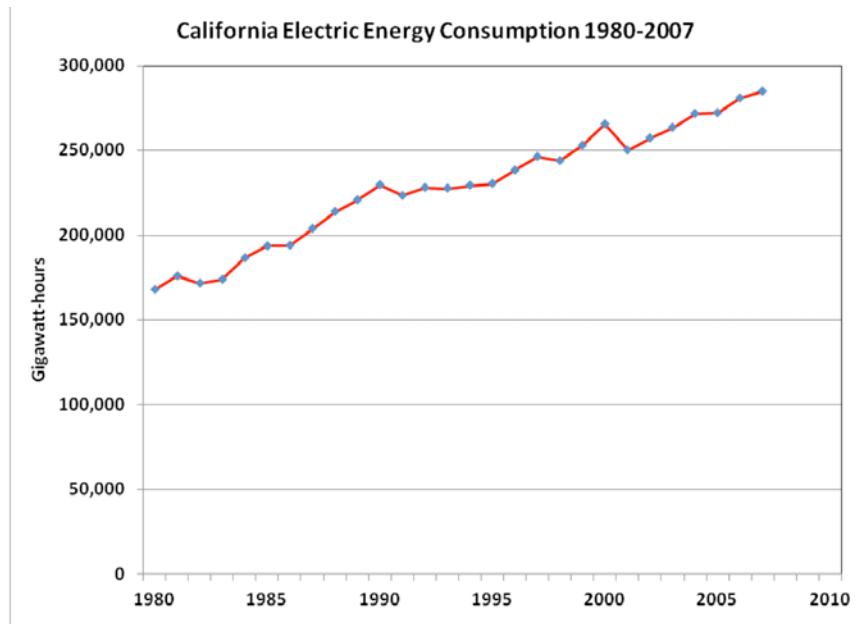
The RETI Stakeholder Steering Committee<sup>8</sup> (SSC) recognizes the uncertainty in the estimate of the renewable net short and, as explained in the Executive Summary of the RETI Phase 1B Final Report, recommends that it be updated periodically in the future as further information becomes available.

New facilities identified by RETI which future events render unnecessary need not be constructed. Nevertheless, the SSC believes that the current estimate of the renewable net short is an appropriate value to be used for prudent transmission planning purposes.

This paper provides additional perspective on RETI's estimate of the renewable net short and briefly examines California energy scenarios which could reduce the need for development of remote renewable energy resources and associated transmission.

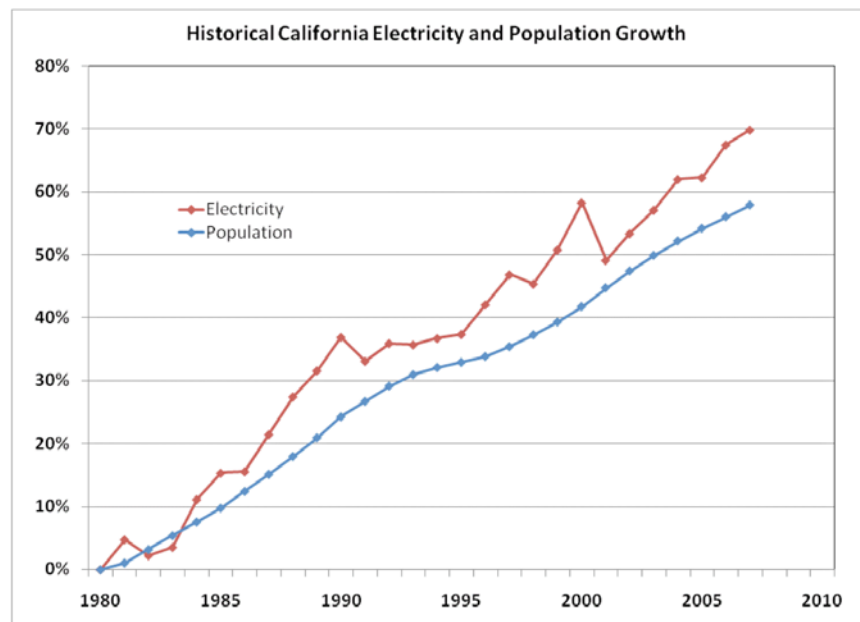
## **2. Demand for Electricity and California Population Growth**

Consumption of electric energy in California has grown with population since 1980 at an average annual rate of 2.0%, as shown in Figure 1.<sup>9</sup>



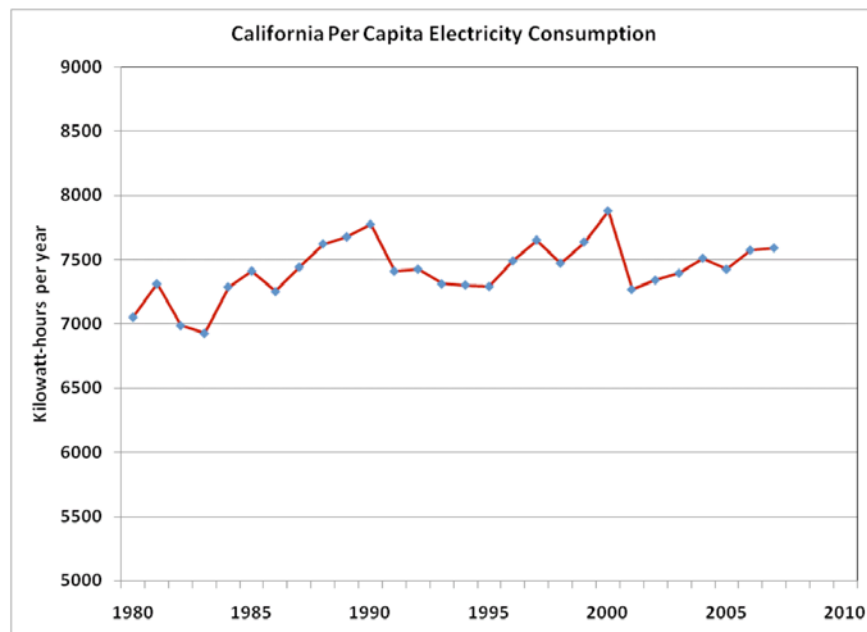
**Figure 1 – Historical Electric Energy Consumption in California 1980-**

The increase in the use of electricity is highly correlated to the increase in California's population. Since 1980 the state's population has grown at a somewhat smaller average annual rate of 1.7% as shown in Figure 2.



**Figure 2 – Historical Electricity and Population Growth in California 1980-**

The fact that California's electricity consumption and population have been growing at similar rates indicates that consumption per capita has remained approximately constant over the period, as shown in Figure 3.<sup>10</sup>

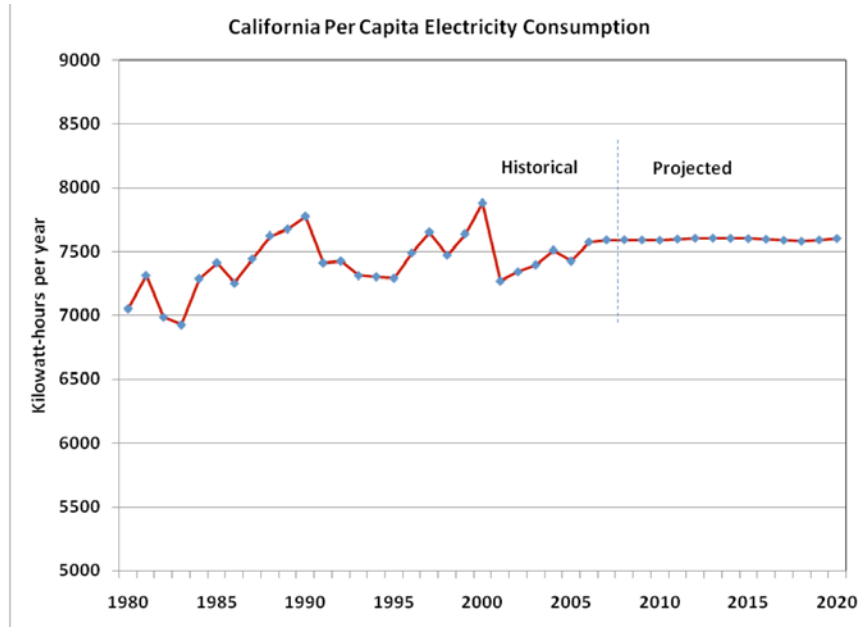


**Figure 3 – Historical California Electricity Consumption Per Capita 1980-**

It should be noted that during this time California has had the most aggressive building and appliance energy efficiency standards in the nation. In addition, California utilities have made substantial investments in energy efficiency programs, more than \$XXX billion since 2000 alone. Recently approved programs require them to invest even more heavily over the next decade. The Loading Order in the state Energy Action Plan requires the CPUC to focus procurement of electricity on all cost-effective energy efficiency savings. Only then can it order procurement of renewables (and lastly of fossil-fired generation). These programs have helped keep per capita consumption from increasing but have not been able to reduce it.

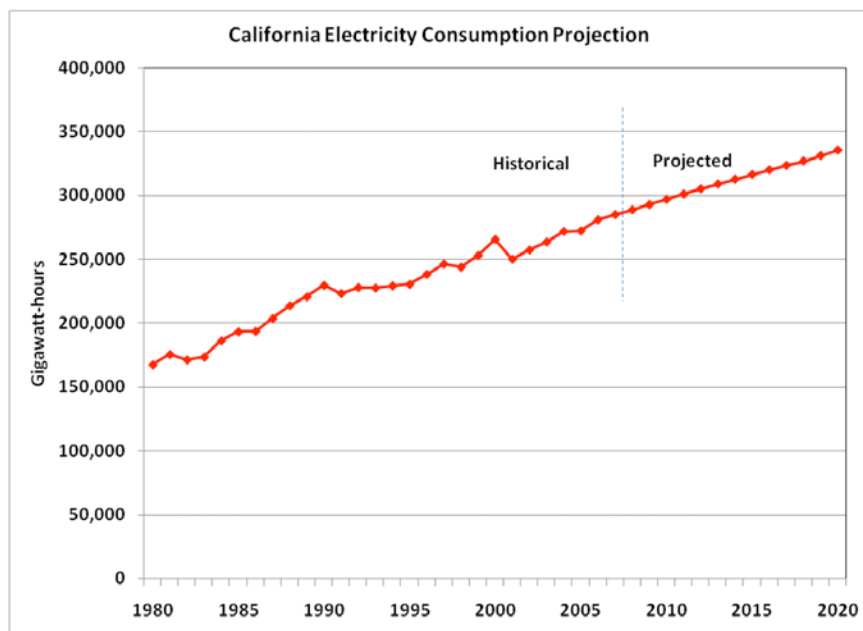
### **Projecting Consumption to 2020**

The question for transmission planners is what electric energy consumption will be in the future and how much of that energy will require new transmission facilities. After consideration of efficiency program projections and other factors, the California Energy Commission (CEC) in its 2007 Integrated Energy Policy Report found the most probable scenario to be one in which per capita consumption continues at approximately today's level, as shown in Figure 4.<sup>11</sup>



**Figure 4 – Per Capita Electricity Consumption in California – Historical and Projected**

Combining the CEC's per capita consumption projection with the California Department of Finance (DOF) population projections<sup>12</sup> provides a projection of total California electric energy consumption as shown in Figure 5.<sup>13</sup> According to this projection, total electric energy consumption in the year 2020 would be 335,644 GWh, the value used by RETI to estimate the renewable net short.

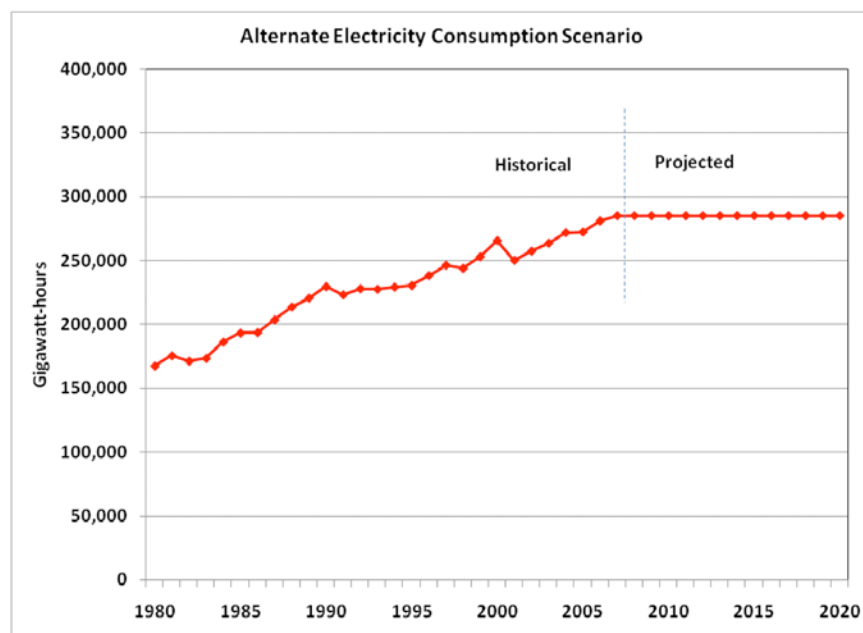


**Figure 5 – Projected California Electricity Consumption 2008 – 2020**

### 3. Accelerated Energy Efficiency Savings

The projected improvements in energy efficiency included in the CEC estimates do not exhaust all cost-effective possibilities, and it is possible that additional efficiency programs can be devised and implemented which would reduce consumption in 2020 below the projected value.<sup>14</sup> If so, the need for additional electricity and associated transmission facilities would also be reduced.

To explore this possibility, it is instructive to examine a scenario which assumes additional aggressive efficiency programs are implemented sufficient to keep total consumption from increasing over 2007 levels. Projected total consumption in such a scenario is shown in Figure 6.



**Figure 6 – Alternate Electricity Scenario with Constant Future Consumption**

Since California population is projected to continue increasing between now and the year 2020, per capita consumption must decrease if total consumption is to remain constant. According to DOF, the state's population in 2020 is expected to be 17.5% larger than in 2007, this scenario requires per capita consumption to decrease by 17.5% as shown in Figure 7.

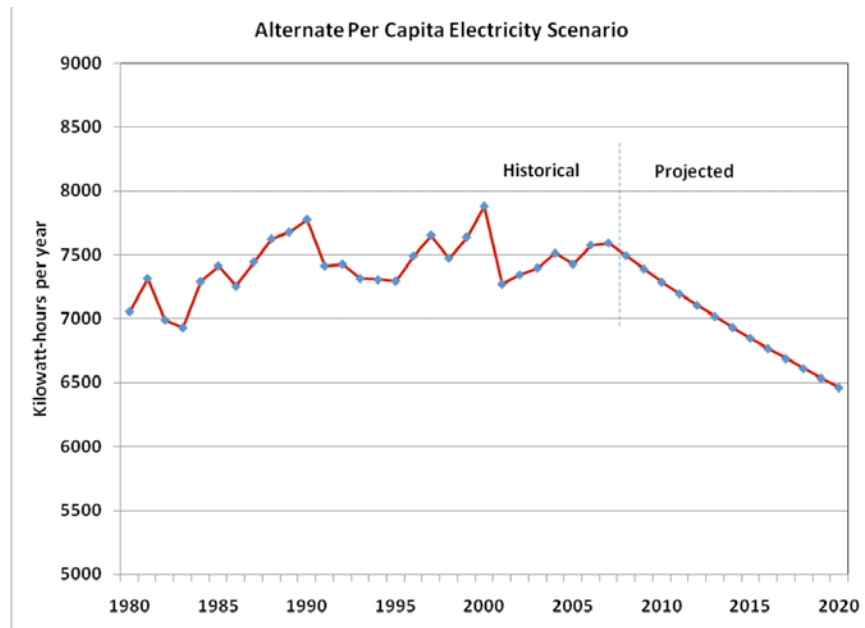


Figure 7 – Per Capita Electricity Consumption in Alternate Scenario

The decline in per capita consumption required to keep total consumption from increasing would be unprecedented in California history, as Figure 6 shows, and would have to begin immediately. Moreover, any increase in the use of electricity in some sectors—such as transportation<sup>15</sup>—would require further reductions in current uses.

California electricity consumption in 2007 was estimated to be 285,197 GWh and is projected to increase by 50,448 GWh by 2020. Avoiding this growth in consumption would reduce the renewable energy required to meet state goals by 16,648 GWh.<sup>16</sup>

A scenario in which total electricity consumption remains at current levels is not impossible. However, there is currently no plan to implement the aggressive reductions in per capita consumption that this scenario would require. In the absence of such a plan and feasible implementation program, RETI believes it would be imprudent to base transmission planning on the expectation that such a scenario will be timely realized.

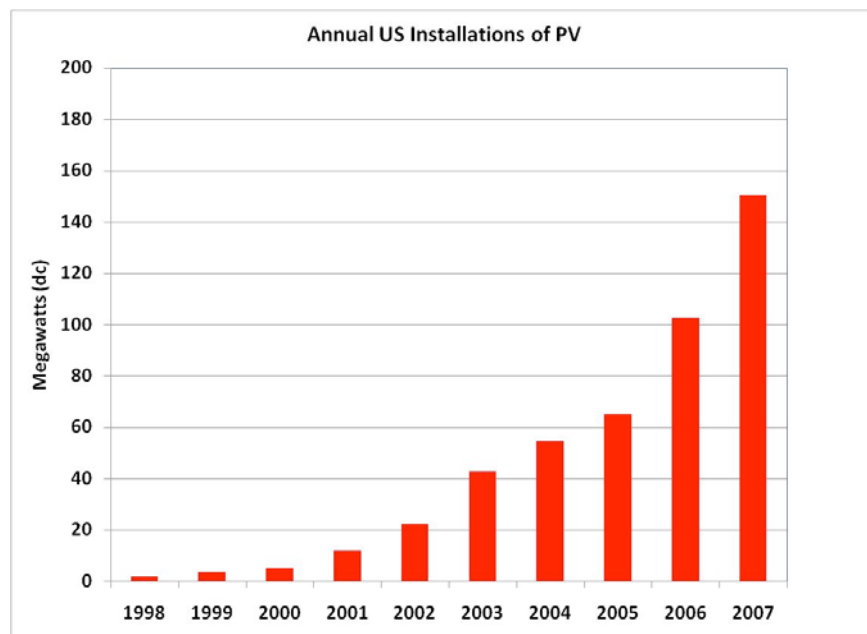
While acknowledging that consumption of electric energy may be lower or higher than projected by the CEC, RETI continues to believe that the projected consumption shown in Figure 5 is an appropriate basis for transmission planning.

#### 4. Accelerated Deployment of Distributed PV

Several parties commenting on the draft Phase 1B report suggested that RETI should assume sufficient PV generation will be deployed in urban areas by 2020 to obviate the need for development of remote resources and associated transmission. This is indeed an attractive scenario. The difficult question for state regulators, utilities and transmission planners is how to assess the likelihood that this scenario will materialize. The largest uncertainties concern the policy support necessary to drive

such deployment; scale-up of manufacturing capacity; and cost. These are discussed below.

US installations of PV have increased markedly in the last decade as shown in Figure 8.<sup>17</sup>

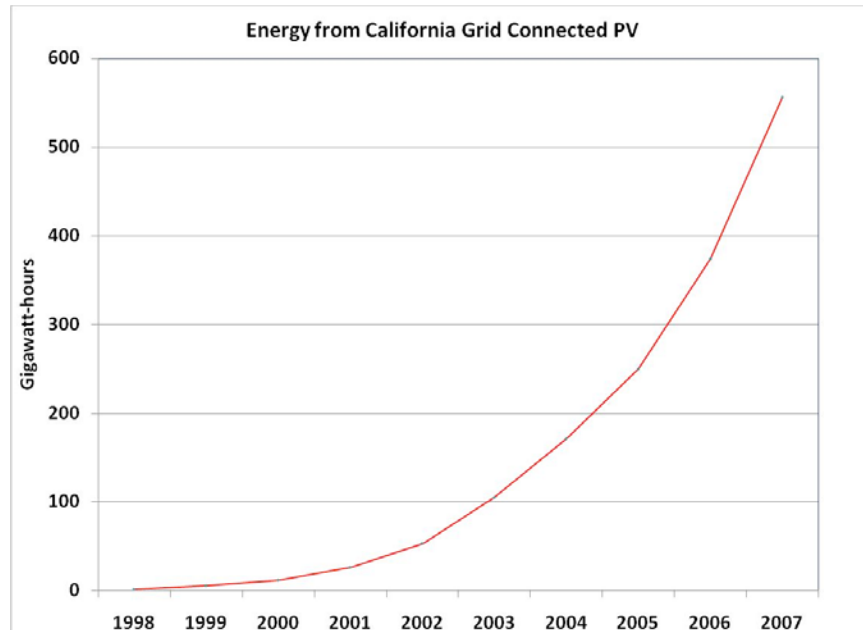


**Figure 8 – Annual US Grid-Connected PV Installations**

The Go Solar California program is projected to add 3,000 MW of grid-connected PV capacity by 2016, producing about 6,570 GWh/yr. This target requires California to add more than six times as much PV in the next eight years as it has in the past eight years shown on Figure 8.

The renewable net short calculation in RETI's Phase 1B Final Report made the unlikely assumption that no additional PV capacity would be added between 2016 and 2020. PV generation in 2020 will almost certainly be somewhat higher than in 2016, the value shown in Table 1. How much higher is the question facing RETI transmission planners.

Electric energy generated by PV systems has increased by a factor of ten in the last five years, to an estimated value of about 800 GWh/yr.<sup>18</sup> Two thirds of all PV installations have been in California, indicating that PV generation in this state was approximately 550 GWh in 2007 as shown in Figure 9, or about 1 per cent of the estimated 2020 renewable net short in California.



**Figure 9 – Estimated Electric Energy from California Grid Connected PV 1998-**

If the trend shown in Figure 9 were to continue, PV generation in California would exceed 5,000 GWh by 2014, exceeding Go Solar California (GSC) goals by a considerable amount. If the same trend were to continue to 2020, PV generation would approach the renewable net short assumed by RETI. If all this energy were produced in urban areas, the need for remote renewable resources and associated transmission facilities would be greatly reduced or eliminated.

### **Key Planning Considerations**

The rapid increase in PV deployment to date has depended and will continue to depend heavily on both state and federal subsidies, at least through 2016. Beyond that date, the pace of deployment is likely to depend on relatively high prices for natural gas and/or of carbon applied to electricity supply, and incentive tariffs for locally generated solar electricity. Key factors in assessing the feasibility of faster deployment of distributed PV than now forecast by utilities and regulators are policy support, technology improvement, installation cost, and manufacturing scale-up.

**Policy Support.** In the past, PV installations have been subsidized by a variety of programs.<sup>19</sup> Go Solar California program subsidies are designed to decline over time and be eliminated by 2016. The assumption underlying the GSC program is that the subsidies will increase installations and thereby manufacturing experience, which will in turn lower costs to a level at which PV generation is competitive with other sources of electricity on a time of use basis. In 2008, Congress extended the 30% federal investment tax credit for eight years, to 2016, and made it available to utilities, thus opening the way to utility company ownership of relatively large-scale rooftop PV installations. This is expected to further bolster deployment of PV (and other solar equipment).

The GSC program is perhaps the most ambitious PV subsidy program in the US, and should help enlarge the capability to support continued rapid growth in PV deployment. But if the federal investment tax credit is not extended beyond 2016, and with California PV subsidies declining through 2016 and absent thereafter, it seems unlikely that installations will continue to increase 10-fold every 5+ years. Component cost, module supply and the diseconomies associated with rooftop installations make it unclear whether even the PV capacity goals of the GSC program will be met.

Feed-In Tariffs (FITs) require Load-Serving Entities to take all electricity produced by eligible generators (PV in this case), and to pay a set rate for that power. They are similar to the California Standard Offer contracts that stimulated renewable energy development in the state in the early 1980s. In Germany, where payment for PV generation has been at above-market rates, FITs have driven rapid growth in PV installations.

In California, the CPUC has approved FITs for small installations at water and wastewater plants. In its 2008 Integrated Energy Policy Report Update, the California Energy Commission recommended that the Public Utilities Commission implement a system of feed-in tariffs for projects up to 20 MW. Tariffs would be based on the cost of generation, but not to exceed the Market Price Referent, or wholesale cost of electricity.

Legislation introduced in the California Senate would create a Feed-in Tariff program in statute. The proposed legislation would also set payment at the Market Price Referent, but allow the CPUC to adjust the payment rate to reflect the value of electricity generated on a time of delivery basis. It would, however, cap the cumulative generating capacity able to receive the FIT rate at 500 MW. Such a program does not appear likely to be sufficient to drive PV installation beyond the GSC target, and legislation establishing larger goals may be necessary to support increased deployment beyond current targets.

**Manufacturing and Installation Cost.** There are encouraging signs that the cost of PV installations will continue to decline, perhaps substantially. “Thin film” PV collectors are less expensive to manufacture than conventional crystalline silicon modules. Given sufficient sales volume, economies of scale in thin film (and other PV technology) manufacturing could reduce the cost of PV installation and energy generated, perhaps to levels comparable to current energy prices.

For example, one thin film manufacturer has entered into a contract with Pacific Gas & Electric Company to generate electricity at a price believed to be competitive with conventional sources.<sup>20</sup> This large thin film PV project is, however, located in remote San Luis Obispo County and requires access to the high-voltage transmission grid.

Thin film PV is less efficient than silicon PV and therefore requires substantially more collector area (i.e., many more commercial or residential rooftops or ground area) to generate comparable amounts of electric energy.

The installation cost of rooftop PV systems is an even larger economic factor. Because of the custom design and diseconomies of scale associated with residential and commercial PV systems, the cost of installing such systems is unlikely to decline significantly. Smaller PV systems in urban areas will likely remain considerably more

expensive than larger utility-scale projects. Relying heavily on residential and commercial PV installations thus increases the total cost of meeting state renewable energy and GHG targets. For calibration, meeting current targets solely with residential/commercial PV installations would require installations on more than 33 million rooftops across the state.

An alternative scenario considered by RETI assumes that medium-sized thin film PV installations of about 20 MW can be located close to urban areas and require no significant new transmission facilities. Each such installation would require approximately 200 acres of land. To meet the renewable net short, more than 1,000 of such installations would be required occupying approximately 200,000 acres of land in or near urban areas. State agencies and utility companies are now evaluating availability of land near existing substations to accommodate such installations, and the electrical capacity of those substations. This will help determine the feasibility of such a development approach. Some substations have already been found to have the capability to support 20 MW-scale PV installations. But at this point, it appears unrealistic to assume that many hundreds of such 20-MW projects can be deployed by 2020.

**PV Manufacturing Capacity.** Worldwide shipments of thin film PV collectors totaled about 500 MW in 2008.<sup>21</sup> Meeting Go Solar California goals (3000 MW in the year 2016) with thin film PV would thus require six times this volume. Meeting an even larger percentage of RPS goals with PV would require module production on a much larger scale.<sup>22</sup> A central question for all interested parties is how quickly worldwide manufacturing capacity, and the supply chain on which it depends, can be ramped up.

PV manufacturing technologies are immature relative to other renewable generating sources. They can be expected to continue to develop so for some time, as PV generating technologies themselves continue to evolve rapidly. Raw material supply required for PV manufacturing now matches current demand and will have to increase proportionally to support expanded manufacturing.

Rapid addition to PV manufacturing plant and equipment depends on availability of financing; and on consistently increasing customer demand. Such demand in turn requires consistent policy support. Current economic conditions complicate the assessment of all of these key factors.

For the last decade, PV demand in the US has lagged that in many other countries. Worldwide demand is expected to continue to increase, along with demand from other US states. The competition for limited supply of PV modules may affect the cost and schedule for meeting California renewable energy goals with a larger percentage of PV than now forecast.

## **5. Development Cost and Risk Factors Underlying Transmission Planning Assumptions**

RETI's mission calls for identifying transmission facilities that would be required to enable 33% of the state's electricity to be generated from qualified renewable energy resources by 2020. As described above, RETI assumes that total consumption of electric energy in 2020 will be 335,644 GWh. 33% of this value is 110,763 GWh, the

amount of energy from renewable resources required to meet the state's goal, assuming that total consumption increases as projected.

Renewable energy generated from existing facilities and new facilities now underway is estimated to be 36,807 GWh.<sup>23</sup> An assortment of new renewable generation technologies with limited potential—to extract electric energy from ocean currents and waves, for example—are estimated to come on line by 2020 and supply an additional 3,134 GWh annually. Since some of these technologies have not been proven commercially, this estimate may be overly optimistic but nevertheless has been included in RETI calculations of the renewable net short.

Assuming that the GSC program represents the total energy expected from PV systems by 2020, the contributions to the 33% goal from various sources are as shown in Table 1.

33%	Existing	Under Construction	PV (a)	Small (b)	Net Short (c)
110,763	35,545	1,262	3,285	3,134	67,536
(a) Energy from GSC program only. (b) Includes generation from anaerobic digestion, landfill gas, small hydro, marine current, marine wave. (c) Numbers may not add exactly due to independent rounding.					

Table 1. Projected California Renewable Energy Supplies in 2020 to Meet 33% Goal (GWh)

Forecasted demand for electricity in 2020 on which the renewable Net Short shown on Table 1 is based assumes that all energy efficiency programs now identified to be put in place over the next ten years will achieve their targeted level of electricity savings. This substantially reduces the amount of electricity having to be supplied from renewable resources pursuant to RPS mandates.

Under current planning approaches, roughly 10% of the renewable Net Short (~6,000 GWh/yr) would be supplied by distributed PV, with the remainder supplied by large-scale geothermal, solar and wind projects. Changing this mix to reduce the amount of renewable energy provided by large-scale, remote projects (and thus the amount of new transmission required) would require greater than forecasted reduction in electricity demand, through expanded energy efficiency programs, and greater than forecasted deployment of distributed generation, especially PV. Supplying the renewable Net Short with substantially more distributed PV than now forecast could raise the total cost of meeting RPS requirements by large amounts.

**Relative Costs of Large-Scale vs. Distributed Renewables.** Meeting a 33% RPS (~67,000 GWh/yr) with a mix of large-scale projects would require about 17,000 MW of new geothermal, solar and wind generating capacity.<sup>24</sup> Meeting a 33% RPS with PV projects would require more than double that amount, or about 38,000 MW of new

generating capacity, because PV generates electricity about 20% of the hours in the year.

Using the capital costs for each generating technology in the RETI Phase 1B Final Report, the weighted average cost of the large-scale projects is about \$3,800/kW. The cost of installing 17,000 MW of geothermal, wind and solar projects would be roughly \$66 billion. The cost of PV generating technologies is much less established. Black & Veatch found forecasts of crystalline silicon PV costs to be \$7,000/kW in the year 2016. Black & Veatch also performed a sensitivity analysis in the RETI Phase 1B Final Report using projected thin film costs of \$3,700/kW, with the caution that such a cost has not yet been demonstrated. Using an optimistic cost assumption for PV technologies of \$5,000/kW (in the same range of projected geothermal and solar thermal costs) would increase the cost of meeting a 33% RPS to more than \$190 billion, or three times the cost of meeting the RPS with a mix of large-scale projects.

**Transmission Development Timelines and RPS Failure Risk.** Transmission facilities require an average of seven-ten years to plan, permit, engineer and construct. Transmission projects being planned today will be unlikely to be placed in service before 2015. Planning for transmission necessary to deliver renewable energy by 2020 will have to be completed in the next few years.

Deferring transmission planning and approval in favor of heavy reliance on deployment of distributed PV generation thus runs the risk that the state would not be able to meet its renewable energy and GHG goals if PV manufacturing and installation proves unable to scale up as rapidly as required.

RPS planning and procurement must target a rate of PV deployment able to be achieved despite uncertainties surrounding the consistency, duration and magnitude of policy support for exponential increases in PV deployment; technology evolution and cost decreases; and manufacturing capacity expansion.

## Conclusion

In combination, the factors outlined here provide a framework for assessing the amount and capacity of new transmission facilities that should be planned to support remote geothermal, solar and wind generating projects.

The RETI Stakeholder Steering Committee (SSC) recognizes the uncertainty in the estimate of the renewable net short and recommends that it be updated periodically in the future as further information becomes available.

New facilities identified by RETI which future events render unnecessary need not be constructed. Nevertheless, the SSC believes that the current estimate of the renewable net short is an appropriate value to be used for prudent transmission planning purposes.

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<sup>1</sup> RETI mission statement, available at: [www.energy.ca.gov/reti](http://www.energy.ca.gov/reti)

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<sup>2</sup> California Environmental Quality Act (CEQA); National Environmental Policy Act (NEPA).

<sup>3</sup> RPS legislation

<sup>4</sup> Governor Schwarzenegger Executive Order S-14-08, November 17, 2008.

<sup>5</sup> This value does not include electricity generated by individual customers for their own use. One gigawatt-hour (GWh) is equivalent to one million kilowatt-hours (kWh).

<sup>6</sup> RETI Phase 1B Final Report, Section 3.8.

<sup>7</sup> id.

<sup>8</sup> The SSC is comprised of 29 participants representing a wide variety of interested parties, including regulatory agencies, utilities, renewable energy developers, environmentalists, consumers and others. A list of SSC members is available on the RETI web site.

<sup>9</sup> California Energy Commission, "Statewide California Energy Demand 2008-2018, Staff Revised Forecast.

<sup>10</sup> Per capita consumption represents the average individual's share of the state's total electric energy consumption, not merely consumption for which the individual is directly responsible. Per capita consumption is computed by dividing total energy use by total population.

<sup>11</sup> IEPR 2007. Note that the CEC projections reported extend only through the year 2018. Energy consumption for 2019 and 2020 has been projected at a rate of increase equal to 1.013% per year.

<sup>12</sup> DOF population projections

<sup>13</sup> IEPR reference.

<sup>14</sup> Reference IEPR alternate EE scenarios.

<sup>15</sup> Bonds to construct an electrified intrastate high speed system were approved by the electorate in November 2008. In addition, the use of electricity for private vehicles such as plug-in hybrids is also being considered.

<sup>16</sup>  $33\% \times (335,645 - 285,197) = 533\% \times 50,448 = 16,648$ .

<sup>17</sup> "US Solar Market Trends 2007", Larry Sherwood, Interstate Renewable Energy Council, August 2008. Chart data from Figure 1.

<sup>18</sup> Estimated from values in the chart assuming an average capacity factor of 20%. Note that chart values are for direct current (DC) capacities, prior to conversion to alternating current for connection to the grid.

<sup>19</sup> **Reference PV programs.**

<sup>20</sup> This project is, however, located in remote San Luis Obispo County and will use the transmission grid. Reference OptiSolar San Luis Obispo contract.

<sup>21</sup> RETI Phase 1B Final Report, January 2009, p. 5-31.

<sup>22</sup> The RETI Phase 1B Final Report found (p. 5-31) that 30,000 MW of thin film PV would meet nearly 80 percent of the California RPS. This would require 60 times more thin film manufacturing capacity than now exists.

<sup>23</sup> Sources of qualified renewable energy technologies assumed to contribute to California energy supplies by 2020 are described in the Phase 1B report, section XXX.

<sup>24</sup>